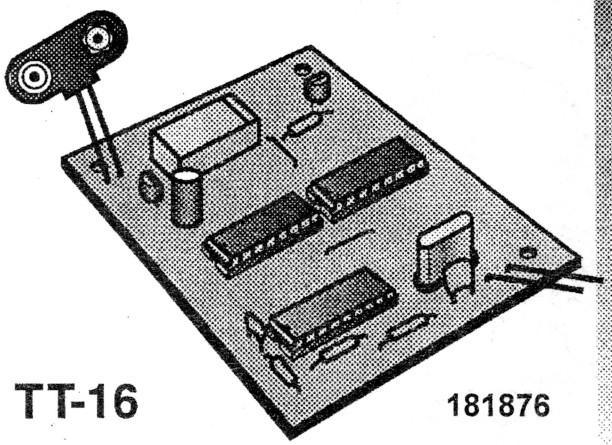
# Sweet 16 TONE DECODER

**Operates great through phone lines, radios or scanners.**



TT-16

181876

JAMECO®

ELECTRONIC COMPONENTS

COMPUTER PRODUCTS

12/18/00

The **SWEET 16 TONE DECODER** detects "Dual Tone Multi-Frequency" data (those sounds you hear when pushing buttons on your phone), and - *when each individual button is pressed* it sends a unique voltage to the electronics on the printed circuit board which activates a circuit on or off. There are 16 different touch tones, 12 of which are on a normal phone; special key pads have 4 additional buttons (A, B, C, D,). This decoder gives an output voltage for all 16 touch tones. The **Sweet 16 Tone Decoder** has on the printed circuit board one (1) relay and driver circuit. If you want to use all 16 you can build your own board with 16 relays and driver circuits on it, or to get fancier use a flip-flop IC to achieve a "toggle" effect (push ON, push OFF), or a 555-timer to provide a timing effect (on for 5 minutes, then off) - the choices are almost unlimited. Any one output may be connected to onboard relay circuit.

***The* TT-16 DECODER KIT *provides a design platform you can use your imagination to build on.***

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# THEORY OF OPERATIONS

Each DTMF tone contains one high frequency and one low frequency. For instance, by pushing your phone's "1"button, you hear a tone containing 697 Hz and 1209 Hz. The **SWEET 16 TONE DECODER**'s first job is to differentiate these tones. Obviously, if a tone of 697 Hz and 1209 Hz is detected, the unit must know it's receiving a "1". If any other noise occurs, it must know it's *not* receiving a "1". (The same principle applies to all DTMF tones). Luckily, there's an Integrated Circuit that does this job for us. It's the MT8870, and we label it U1on the Schematic Diagram. The DTMF tones go into Pin 1 of this chip.

When any valid DTMF tone appears at Pin 1, U1 responds by placing the tone's corresponding code, in binary form, on Pins 11, 12, 13, and 14. (Continuing with our example, if a 697 Hz/1209 Hz tone is at Pins 1 and 2, a"1" in binary form appears on Pins 11, 12, 13, and 14. This means Pin 11 is 5 volts, and Pins 12, 13, and 14 are 0 Volts.) At the same time, Pin 10 of U1 goes high when *any* valid DTMF digit is received (it's 0 otherwise.)

To translate the 4-bit binary output into 16 individual voltages, two 74C238 3-to-8 line Decoder/Demultiplexer chips are utilized. These are designated U2 and U3 on the schematic. They accept *three* binary weighted address inputs (pins 1, 2, and 3) and, when enabled, provide 8 mutually exclusive active HIGH outputs (pins 15, 14, 13, 12, 11, 10, 9, and 7.) This is great, except that we have *four* binary weighted address inputs, and we want *16* mutually exclusive active HIGH outputs.

Of course, that's why two of them are used, and the key is the phrase "when enabled." The 74C238 features three enable inputs: two active LOW (pins 4 and 5) and one active HIGH (pin 6.) *Every output will be LOW unless pins 4 and 5 are LOW and pin 6 is HIGH.*

Look at how these pins are wired. Pin 10 of U1, remember, is

HIGH *only* when a valid DTMF tone is received. This pin is connected to pin 16 (Vcc) of U2 and U3 (thus supplying power to them, and insuring both are completely cut off when no tone is received.) It's also connected to pin 6 (active HIGH) of U3. So the active HIGH condition for U3 is fulfilled when *any* DTMF tone is present. But what about the active LOW condition?

U3 is the chip that handles the "low-numbered" DTMF tones (D, and 1 through 7.) Pins 4 AND 5 must be LOW for this chip to work. Note that pin 5 is simply grounded, so it's always low. Pin 4, on the other hand, is connected to pin 14 of the 8870 - the "fourth" or "high" bit of the binary numbers. Realize that for tones D through 7, that output will be LOW. Thus, pin 4 of U3 will be LOW, and U3 will respond. But, for tones 8 and above (including 0, *, #, and special tones A, B, and C), pin 14 of U1 will be HIGH., pin 4 of U3 will be HIGH, and so U3 *won't* respond.

So U3 only works for tones D and 1 through 7. We want U2 to work only for tones 8 through 0 , *, #, and A through C. Let's examine its enable pins. The active LOW pins (4 and 5) are grounded, so they're always low. The active HIGH pin (6), on the other hand, is tied to pin 14 of U1. Again, *this is the upper bit of the binary numbers.* Here's the thing: this pin is *low* for tones D and 0 through 7, but *high* for tones 8 and above, which is *just what we want.* U2 therefore does *not* respond for low tones, but *does* for high tones. So we've achieved our objective: a four-bit binary number (the 8870's output) is translated into 16 mutually-exclusive active HIGH outputs.

# APPLICATIONS

OK - you push one button on your phone, you get one exclusive positive voltage. You release the button on your phone, the voltage goes away. "What," I hear you saying, "are the kinds of things I could actually *do* with this capability?"

The first answer is: all by itself, not much. As stated before, ***the* TT-16 DECODER *provides a design platform you can use your imagination to build on.*** It's a *basis* for further design and experimentation on your part, not a complete solution. In many ways, that's good. The **TT-16 DECODER** functions as a "black-box component:" DTMF tone **INPUT**, mutually-exclusive voltage **OUTPUT**.

***So let your imagination run wild!***

**(1) Custom Signalling Devices:**
You're working in the basement. Your wife (husband, child, etc.) requires your attention. You picks up the phone, presses the "*" key, and the **SWEET 16 TONE DECODER** you've installed makes a buzzer go off. Hey, as long as you have a phone jack down there, why go to the expense and bother of installing long runs of wire just to ring a little bell? Use that phone line for signalling each other!

Or how about turning a signal light on? Use a 7474 (or equivalent) flip-flop device to provide a "toggle switch" effect (push once - on, push once - off.) OR, use a 555-Timer chip to keep the light on a certain number of seconds (minutes, hours) before it shuts off automatically (incidentally, our ET-1 or ETC-2 Electronic Timer kits work perfectly in this application.)

**(2) Remote Control Devices:**
You're driving home on a dark and foul night when suddenly, slapping your head in disgust, you realize that you failed to turn *any* lights on in your house. Luckily for you, you built the Rainbow **SWEET 16 DECODER.** You have it hooked up to *several* devices in your home, because you built a "relay board," complete with latching circuits. You use your cellular phone to call

home; your trusty answering machine tells you to "leave your message at the beep" - but instead you press the "1", "2", and "0" keys, and - *almost like magic* - three strategically-placed lamps pierce the darkness. Lets say you connect Rainbow kit **AA-1** the Super Snooper Big Ear to button #3 now you can even listen to what's going on in your living room.

Note: with the TT-16 kit *as you bought it*, has a relay on board to handle up to 1.5A. for a single function, you could control one lamp, if you pay attention and wire the relay in "latching" mode. Pretty cool, eh?

Or, try this: You bought a big relay (contacts: 20 Amps, but uses 110 volts AC for the coil) *really cheaply* on the surplus market. You did this, not for a specific reason, not with any actual *use* in mind for the relay, but just because it seemed to be a neat thing to have around. Now, though, your spouse is mad at you, and is demanding that you either find a use for it or throw it out! So you cleverly use the **TT-16 Kit**'s relay to feed 110 volt AC to the big relay's coil (the TT-16 relay being wired in latching mode, of course), and use the big relay's contacts to control an Air Conditioner.

Now! It's a blisteringly-hot, really steamy day. You're driving home (again) when your spouse remembers: *we forgot to turn on the Air Conditioner.* Oh, no! But you, struggling to suppress a tiny little smirk, dial your home on the cell phone, wait for the answering machine, press the "#" key, and smugly inform your spouse that the situation is resolved. And, you're sure to mention the role that big relay played!

Note: **Always use extreme caution and follow all safety rules when working with 110 or 220 Volt AC house current.**

**(3) Spy Devices:**

In addition to controlling lights and air conditioners over the phone, you could easily connect our **AA-1 Super Snooper Big Ear** Amplifier kit to the phone line using the TT-16. Then you could call home and listen in, answering such important questions as "Is a burglar in my home right now?" or "Is the dog barking

and annoying my neighbors right now?" or "Did the kids go to bed, or are they watching an X-rated TV show right now?"

Or how about a secret communications/signalling device? Notice on the Schematic Diagram that a 3.58 MHz (color burst) crystal is connected to pins 7 and 8 of the 8870 chip. Suppose you were sending control tones over a radio link, and you had a custom tone generator (based on a chip like the 5088) for that purpose. Normally, you'd use a 3.58 MHz crystal on that end, too.

*But* -- an interesting feature of sampled-data signal processors is that their characteristics change when their clock rates change. Many of these chips can be run with slightly different crystals to detect different frequencies. Get the picture? For instance, use a 4 Mhz crystal on each end, rather than the specified 3.58 MHz crystal. The higher clock rate causes the generator's output tones to be higher in frequency and the receiver's recognition frequencies to be shifted by about the same proportion. The overall effect is to provide tone signalling at higher frequencies than the standard DTMF assignments, shifting the digits and yielding a private code. You could use the **TT-16 Tone Decoder** exactly as before, only now nobody could listen in on you!

**(4) Amateur Radio Applications:**

***Capable of 16 Different Simultaneous Functions***

All 16 DTMF tones are decoded to logic level outputs.

- **Repeater Controls**

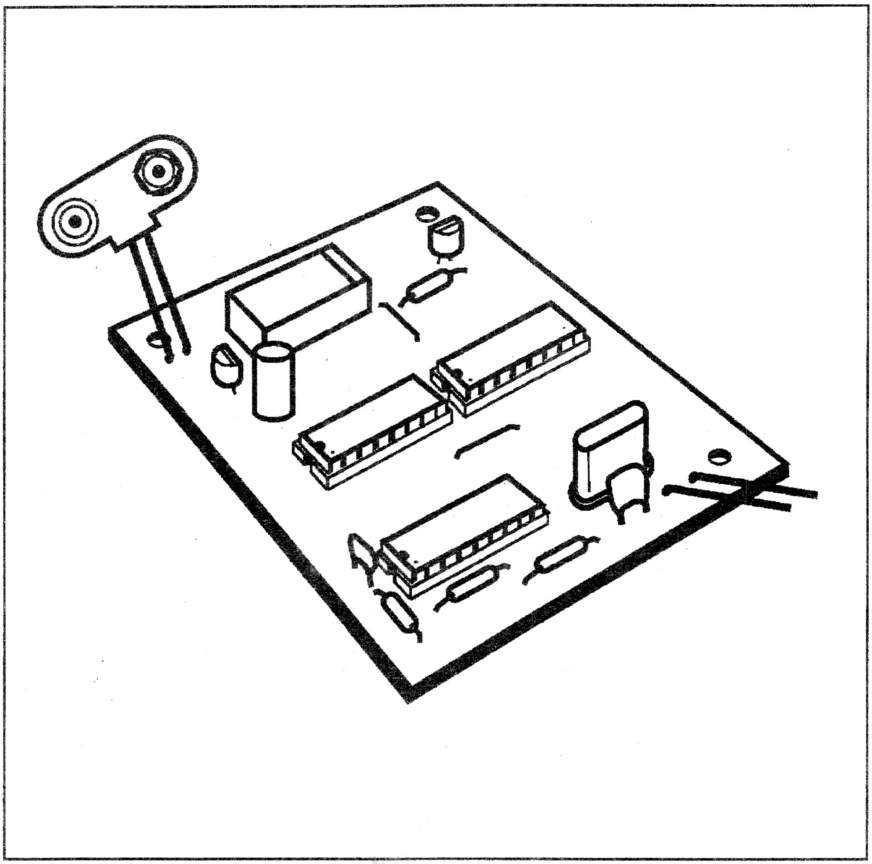
Remember the TT-16 DTMF decoder is capable of decoding 16 different functions at any given time. If you operate a repeater, you could set up the TT-16 so that each button on the keypad of the user's radio would activate any particular function.

***For Example:***

The #A button connects to the Auto Patch
The #1 button connects gives the weather
The #2 button gives current time
The #3 button connects you to transmit in on one frequency and out on another.

***...and so on.*** Recall what we've said many times in this manual:

***The TT-16 Decoder Kit provides a design platform you can use your imagination to build on.*** Go ahead, allow your users the choice of 16 different functions at the touch of a button!



# PARTS LIST

*TT-16*

**Resistors:**

| | | | |
|---|---|---|---|
| ( ) | 2 | R1, R2 | 100K resistor (brn blk yel) |
| ( ) | 1 | R3 | 300K resistor (org blk yel) |
| ( ) | 1 | R4 | 2.2K resistor (red red red) |

**Capacitors:**

| | | | |
|---|---|---|---|
| ( ) | 2 | C1, C2 | .1uF Mono cap (.1 or 104) |
| ( ) | 1 | C3 | 10 uF electroletic cap |

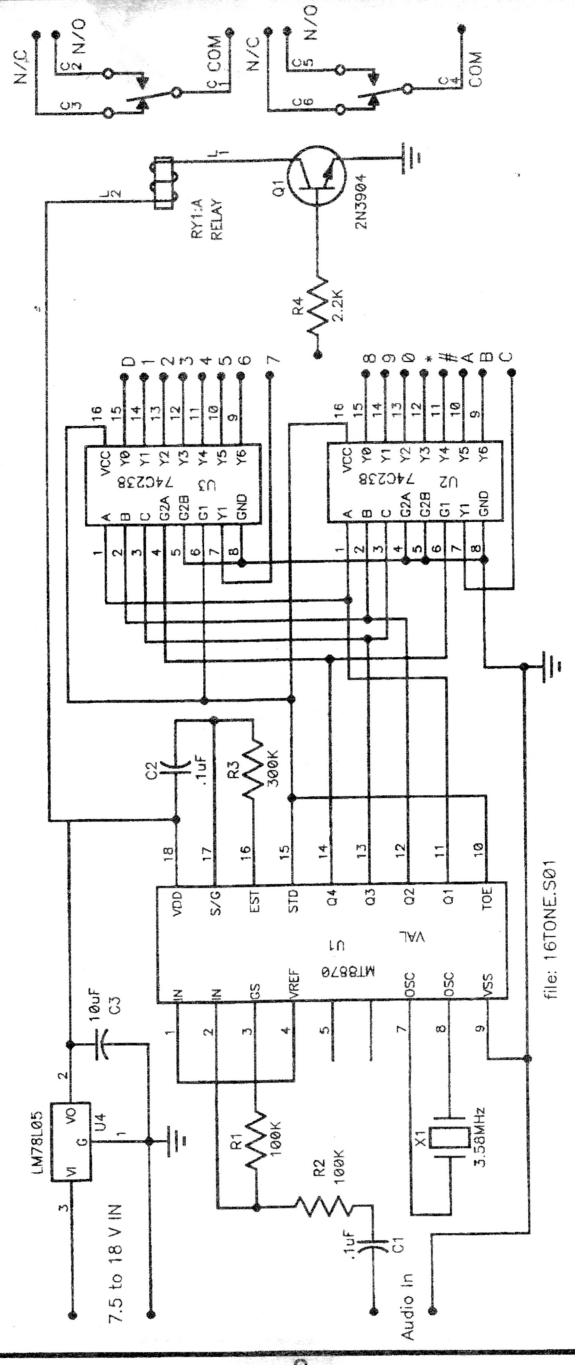
**Semiconductors & IC's:**

| | | | |
|---|---|---|---|
| ( ) | 1 | U1 | MT8870 DTMF Decoder IC |
| ( ) | 2 | U2 ,U3 | 74C238 IC |
| ( ) | 1 | U4 | 78L05 5v regulator |

**Miscellaneous:**

| | | | |
|---|---|---|---|
| ( ) | 1 | X1 | 3.579545MHz Crystal |
| ( ) | 1 | Q1 | NPN transistor 2N3904, 2N2906 or 2222 |
| ( ) | 1 | RY1 | DPDT RELAY |
| ( ) | 1 | SOCKET | 18 pin IC socket |
| ( ) | 2 | SOCKET | 16 pin IC socket |
| ( ) | 1 | CON1 | 9v battery snap |
| ( ) | 1 | P C BOARD | 080-00313 |

# SCHEMATIC


N/C
N/O
COM
RY1:A
RELAY
Q1
2N3904
R4
2.2K
74C238
U3
U2
MT8870
U1
VAL
C2
.1uF
R3
300K
10uF
C3
LM78L05
U4
7.5 to 18 V IN
R1
100K
R2
100K
.1uF
C1
Audio In
X1
3.58MHz
file: 16TONE.S01

# KIT ASSEMBLY INSTRUCTIONS

Separate and identify each component in your kit. Our instructions will lead you through the assembly process in the most logical manor, the parts that are the lowest profile on the board-up to taller parts.

**FOR EACH STEP:**

1. Find the proper components,
2. Insert the leads so the part is flush with the Printed Circuit Board (PCB).
3. Solder and cut off the excess leads.
4. Check off and proceed to the next step.

**RESISTORS:**

( ) Insert jump 1 (use resistor lead cutoff)
( ) Insert R1, R2 100K resistor (brn blk yel)
( ) Insert R3 300K resistor (org blk yel)
( ) Insert R4 2.2K resistor (red red red)

**CAPACITORS:**

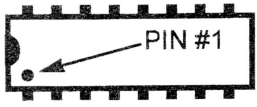
( ) Insert C1, C2 .1uF Mono cap (.1 or 104)
( ) Insert C3 10 uF cap (watch polarity)

**SEMICONDUCTORS:**

( ) Insert U4 78L05 5v regulator (watch orientation)

We supply IC sockets for all IC'c. Note orientation.

( ) Insert 18 pin IC socket for U1
( ) Insert 16 pin IC sockets for U2 and U3




**Do not insert IC's at this time.**

**MISCELLANEOUS:**

( ) Insert X1 3.579545MHz Crystal
( ) Insert Q1 2N3904 (2N2906 or 2222) NPN transistor (watch orientation)
( ) Insert RYI DPDT Relay

( ) Insert Wires for 9v Battery Snap, Red ⊕ wire, Black ⊖ wire.

**This completes the construction of your 16 Tone Decoder.**

*Check your work very carefully for good solder practice, check for cold soldering, shorts and solder bridges. It's always best to let someone else look it over as well before applying power.*

**If you are satisfied with your construction:**

( ) Insert U1 MT8870 DTMF Decoder Integrated Circuit into it's correct socket. (watch orientation)

( ) Insert U2 & U3 74C238 Integrated Circuits into their correct sockets. (watch orientation)

## TESTING AND TROUBLESHOOTING

NOTE: ***You'll need a voltmeter to test this kit.***

**(1)** Connect your completed kit's audio input to a phone line's red and green wires. Make sure a 7.5v to 18v DC power source is installed. Check *ONE MORE TIME* to make sure the chips are properly inserted in their sockets, and that they're not installed backwards!!

**(2)** Hook up a DTMF telephone to another phone jack in your house (or, buy a telephone-jack "Y" adapter, and connect the TT-16 into one-half of the "Y" and a phone into the other half.) Press every button on your phone in sequence.

***When you press "1", pin 14 of U3 should be +5 volts, and all other output pins should be 0 volts (see schematic). Similarly, pressing "2" makes pin 13 of U3 high, etc. Continue monitoring the output pins of U3 and U2 as you push every phone button. (Note that when you get to "8", you shift to pin 15 of U2.) Each phone button should make its corresponding output pin, and no other, go to +5 volts; the pin should go back to 0 volts when the button is released.***

If Step 2 checks out, please go to **Step 4.**

**(3) IF STEP 2 DOESN'T WORK:**

**(a)** Check parts placement and connections CAREFULLY around U1. Opens, shorts, or missing parts guarantee the unit won't work! Make sure you have +5 volts at the output (pin 2) of the 78L05 Voltage Regulator.

**(b)** If everything looks good, check pins 7 & 8 of U3 with a scope or voltmeter. (Note: *DISCONNECT THE UNIT FROM THE PHONE LINE BEFORE HOOK ING UP THE SCOPE.*) You should see 3.58 MHz

oscillation on both pins; the amplitude of pin 8's waveform is larger. DC Voltage on pin 7 is about 2.44 volts; on pin 8 approximately 2.56 volts. If these conditions are not satisfied, check the connections around X1 (the 3.58 MHz Crystal) carefully

**(c)** Connect the unit to the phone line again. Check Pin 10 of U1 with a voltmeter. It should be 0 Volts until any phone button is pushed, at which time it should go to +5 Volts and stay there as long as the button is pushed. If Pin 10 doesn't go to 5 volts for any tones, check parts placement and connections around Pins 1, 2, 3, and 4 of U1. Pay attention to R1, R2, and C1 (audio input circuit) and C2 and R3 ("steering" circuit). Make sure there are no shorts, opens, etc. You *do* have +5 volts at pin 18 of U1, don't you?

**(d)** Once the above condition is met, press "1" on your phone. Pins 10, 11, and 15 of U1 should go to +5 volts, and pins 12, 13, and 14 of U1 should be 0 volts. When you let up on the "1", pins 10, 11, and 15 should go back to 0 volts and, of course, pins 12, 13, and 14 should stay at 0 volts.

***If you cannot get the condition outlined in (d) to work, please turn to page 15 of this manual for information on how to have your kit repaired.***

**(e)** If the condition outlined in (d) works, but you still have no output at pin 14 of U3 when the "1" button is pushed, check your work carefully around chips U3 & U2 for shorts, opens, etc. *With the "1" button pushed,* insure that +5 volts appears at pin 16 of U3 and U2. Pins 4 & 5 of U3 should be low, and pins 1 & 6 should be +5 volts. Pins 4 & 5 & 6 of U2 should be low, and pin 1 should be +5 volts. Keep checking your work until this condition is met.

***If you cannot get the condition outlined in (e) to work, please turn to page 14 of this manual for information on how to have your kit repaired.***

**(4)** Using a clip lead or a piece of hookup wire, ***carefully*** connect +5 volts (i.e., pin 2 of the 78L05 regulator) to the side of R4 ***not*** hooked up to the transistor. (**NOTE**: If you make a mistake and touch the other side of R4 with +5 volts, you'll probably need a new transistor *immediately*!) When +5 volts is applied to R4 in this way, you should hear the relay click (it may be quite soft). You may use an ohmmeter to check out the relay switching if you want to.

If this step doesn't work, check your wiring around R4, Q1, and the relay itself. With the relay off, +5 volts should appear at the collector of Q1; with the relay engaged, Q1's collector voltage should be very low. Although new relays have been known to be defective, it's really not very likely, so look carefully to find the trouble's source before blaming it.

***If you cannot get the condition outlined in (4) to work, please turn to page 16 of this manual for information on how to have your kit repaired.***

However, if this step works, **CONGRATULATIONS**! Your **SWEET 16 TONE DECODER** works perfectly. Now, to control one device with any one DTMF tone:

**(a)** Choose whatever tone you wish to use. For instance, say you want to use the phone's "#" sign.

**(b)** On the schematic, the DTMF tone symbols are located just above and below the drawing of R4, and they're keyed to specific output pins of the 74C238 chips. For example, the "#" symbol is located just to the right of pin 11 of U2, so you know that's the "#" output. Any time the "#" tone is detected, this pin will be +5 volts; otherwise, it will be 0 volts.

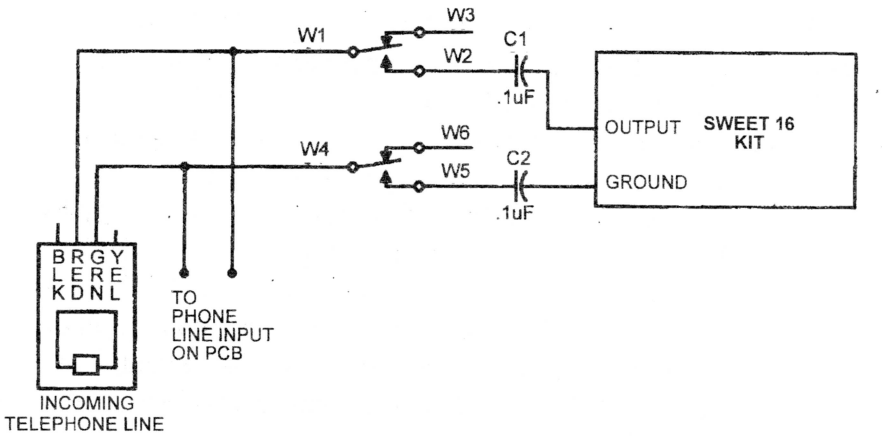
(c) Once you've determined the DTMF tone you wish to use, just run a jumper wire (e.g., a resistor lead) from the relay input point (next to R4) to any one of the 16 holes that you select, labeled 1 through 0, A,B,C.D, or *,#. The hole that you select will determine whitch DTMF tone will activate the relay.

## PROVIDING MORE SECURITY

Suppose you've done all this, and now you're worried because anyone pressing the "#" key on a phone, for *any* reason, turns on your relay. "It'd really be nice," you think to yourself, "if I could enter *several* DTMF tones as a kind-of 'password,' and *then* use my TT-16 kit to control up to 16 devices by phone."

***The Rainbow* DTMF DECODER (DTMF-1) *kit solves this problem. This kit allows you to "teach" it a code of up to 15 DTMF tones. Only after receiving this code does the unit engage its relay, which remains energized until either a button on the unit is pushed, or the original DTMF code (preceded by a "#" tone) is entered.***

The secret is to run the phone line into the common relay connection of the **DTMF DECODER**, and run its normally ***open*** relay contacts to the audio input of the **SWEET 16 TONE DECODER.** (See Diagram below)



Now, someone can press the "#" (or any other) phone button all day long, but it won't make it to the **TT-16** ***unless the proper code energizes the*** **DTMF DECODER'S** ***relay***. **Then** and only then will the DTMF decoder do its job of up to 16 different simultaneous switching functions. And of course, once the **DTMF DECODER**'s relay is *dis*engaged, complete security is once again introduced!

# ATTENTION KIT BUILDER

***Before soldering board, make sure that you have the ability to completely assemble this kit properly.***

**RETURN POLICY:**

Electronic Rainbow will refund the purchase price on any unopened kit LESS postage and a 15% restocking fee.

**NO REFUNDS WILL BE MADE ON ANY KITS THAT HAVE BEEN TOUCHED WITH SOLDER.**

*Electronic Rainbow will repair any of it's kits sent back for the following costs, which includes return postage to the customer:*

*NO REPAIR WILL BE LOOKED AT UNTIL REPAIR COST IS RECEIVED.*

**THE COST TO REPAIR YOUR TT-16 IS $15.00**

**It doesn't work – now what?**
**If assembled properly all kits work. ALMOST all of the kits we receive for repair have assembly errors.**

Here are some of the more common errors we find.

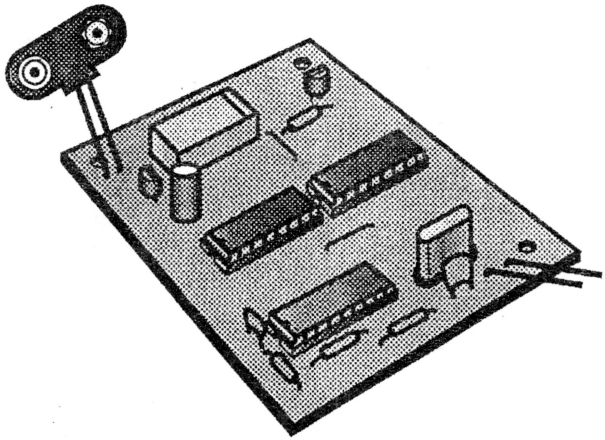
1. **Parts in the wrong holes.**
2. **Solder shorts.**
3. **Parts in backwards.**
4. **Parts which are not soldered or have cold solder joints.**
5. **Wires which are "frayed" and touching other parts.**

*It is very difficult to objectively check your own work. Have some one else look over your completed kit. This can save a lot of time, frustration and money. If you need technical assistance you are welcome to call or write.*

For repair send your kit to:
**Electronic Rainbow Ind., Inc.**
**6227 Coffman Rd. Indianapolis, IN 46268**

Phone **317-291-7262** FAX 317-291-7269
INTERNET: www.rainbowkits.com

*If you must return your kit for repair we must charge for our technicians time. If a part is defective there is **NO CHARGE**. However we cannot warrant the kit builders ability, only the parts.*



## SPECIFICATIONS TT-16

9 volt battery powered
Size: 2 3/4 x 2 1/8 inches
DTMF Decoder Decodes 16 different touch tones through the phone lines, radios, or scanners.
One relay & driver circuit on board.

JAMECO®
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